Fish & Wildlife Division

SPECIES AT RISK

Status of the Slender Mouse-ear-cress (*Halimolobos virgata* or *Transberingia bursifolia* subsp. *virgata*) in Alberta:

Update 2009

Government of Alberta

Alberta Conservation Association

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Update 2009

Prepared for:
Alberta Sustainable Resource Development (ASRD)
Alberta Conservation Association (ACA)

Update prepared by:
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Much of the original work contained in the report was prepared by Ian Macdonald in 2005.

This report has been reviewed, revised, and edited prior to publication.
It is an ASRD/ACA working document that will be revised and updated periodically.

Alberta Wildlife Status Report No. 55 (Update 2009)

August 2009

Published By:

Government of Alberta

Alberta Conservation Association

Publication No. T/218
ISBN: 978-0-7785-8715-6 (Printed Edition)
ISBN: 978-0-7785-8716-3 (On-line Edition)
ISSN: 1206-4912 (Printed Edition)
ISSN: 1499-4682 (On-line Edition)

Series Editors: Sue Peters, Robin Gutsell and Gavin Berg
Illustrations: Brian Huffman
Maps: Velma Hudson

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Telephone: (780) 944-0313 or 1-877-944-0313

This publication may be cited as:

Alberta Sustainable Resource Development and Alberta Conservation Association. 2009. Status of the Slender Mouse-ear-cress (*Halimolobos virgata* or *Transberingia bursifolia* subsp. *virgata)* in Alberta: Update 2009. Alberta Sustainable Resource Development. Wildlife Status Report No. 55 (Update 2009). Edmonton, AB. 28 pp.

PREFACE

Every five years, the Fish and Wildlife Division of Alberta Sustainable Resource Development reviews the general status of wildlife species in Alberta. These overviews, which have been conducted in 1991 (*The Status of Alberta Wildlife*), 1996 (*The Status of Alberta Wildlife*), 2000 (*The General Status of Alberta Wild Species 2000*), and 2005 (*The General Status of Alberta Wild Species 2005*) assign individual species "ranks" that reflect the perceived level of risk to populations that occur in the province. Such designations are determined from extensive consultations with professional and amateur biologists, and from a variety of readily available sources of population data. A key objective of these reviews is to identify species that may be considered for more detailed status determinations.

The Alberta Wildlife Status Report Series is an extension of the general status exercise, and provides comprehensive current summaries of the biological status of selected wildlife species in Alberta. Priority is given to species that are *At Risk* or *May Be At Risk* in the province, that are of uncertain status (*Undetermined*), or that are considered to be at risk at a national level by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Reports in this series are published and distributed by the Alberta Conservation Association and the Fish and Wildlife Division of Alberta Sustainable Resource Development. They are intended to provide detailed and up-to-date information that will be useful to resource professionals for managing populations of species and their habitats in the province. The reports are also designed to provide current information that will assist Alberta's Endangered Species Conservation Committee in identifying species that may be formally designated as *Endangered* or *Threatened* under Alberta's *Wildlife Act*. To achieve these goals, the reports have been authored and/or reviewed by individuals with unique local expertise in the biology and management of each species.

EXECUTIVE SUMMARY

Slender mouse-ear-cress (*Halimolobos virgata* or *Transberingia bursifolia* subsp. *virgata*) is an herbaceous plant distributed in the mixedgrass prairie on the plains of southeast Alberta and southwest Saskatchewan, and across semi-arid mountain ranges and intervening basins and plateaux of seven western states. It is listed as *Threatened* federally and also provincially by the Saskatchewan government. In Alberta, evaluation of a 2005 provincial status report resulted in a recommended status of *Data Deficient* by the Alberta Endangered Species Conservation Committee and its Scientific Subcommittee. Results of additional surveys in known and potential habitat for slender mouse-ear-cress are incorporated into this updated status report to assist in the evaluation of its provincial status.

Suitable habitat for slender mouse-ear-cress in Alberta is characterized as undulating to rolling native grassland on silty to sandy deposits of fluvial or eolian origin. It may be associated with ephemerally wet depressions and drainages. Fourteen subpopulations are recognized in Alberta: one is ranked as extirpated, one as historical, three as failed-to-find during subsequent surveys and nine as extant. Substantial rare plant search effort over the last few decades, and particularly within the last few years, in apparently suitable habitat has resulted in reports of only a few additional subpopulations of slender mouse-ear-cress. The extent of occurrence of all subpopulations in Alberta is about 9998 km^2; that of only extant ones is about 530 km^2. Considering only extant subpopulations, the area occupied by slender mouse-ear-cress is estimated to be 18 km^2 (the sum of occupied 1-km x 1-km squares). This number could be less than 0.05 km^2, based on the number and maximum size of unique locations in the Alberta Natural Heritage Information Centre database.

The provincial population of slender mouse-ear-cress is estimated to be in the order of several thousand (3000–7000) reproducing individuals in years when conditions are suitable for germination and growth. Data over multiple years at some sites indicate large fluctuations in number of reproducing individuals, depending on environmental conditions such as timing and amount of rainfall in spring. Alberta's extant population of slender mouse-ear-cress is approximately 45 km from the closest known subpopulation in Saskatchewan and 200 km from the nearest subpopulation in the Sweetgrass Hills of Montana. The next nearest known populations are about 450 km south in the Tendoy Mountains of southwest Montana and in the Absaroka Range of northwest Wyoming.

Loss of native grasslands within the range of slender mouse-ear-cress is affecting habitat quality and availability. Native prairie decline is caused primarily by agriculture expansion, urban development, oil and gas development and the construction of transportation and utility corridors, as well as the spread of invasive non-native species in fragmented landscapes. Since 1970, bare ground resulting from agriculture (cultivation) and industrial development has increased 40% and linear disturbance has increased 93% in a regional study area that encompasses all of the range of extant slender mouse-ear-cress subpopulations. The trend in loss of native grasslands is expected to continue. Other potential limiting factors for slender mouse-ear-cress are climate change and altered fire and grazing regimes beyond the range of natural variation.

A draft recovery strategy for slender mouse-ear-cress in Canada has recently been developed by Environment Canada.

ACKNOWLEDGEMENTS

For the original 2005 report prepared by Ian Macdonald:
Bonnie M. Smith (University of Calgary) for her generosity in sharing her experience with the species in Alberta, without which this report would not be possible; Candace Elchuk (Canadian Wildlife Service [CWS]) for sharing information on her relocations in the province from 2004, and for her fresh insight into the habitats of the species; Susan Peters (Alberta Conservation Association [ACA]) for her encouragement in the field survey and research phases of this project and her excellent, thorough and insightful review of this report; Andy Didiuk (CWS) and Robin Gutsell (Alberta Sustainable Resource Development [ASRD]) for their support of the 2002 and 2003 field survey and research phases of this report; Nyree Sharp (ACA) for her review of the final stages of this report; Ksenija Vujnovic (Alberta Natural Heritage Information Centre [ANHIC]) for providing information on the known sites in Alberta; John Rintoul (ANHIC) for information on the reported Rosedale and Cypress Hills sites and conservation issues in Alberta; Sheila Lamont (Saskatchewan Conservation Data Centre [SCDC]), Jeff Keith (SCDC) and Ann Gerry (SCDC) for information on the recent efforts to locate the species in Saskatchewan and clarification of the Cypress Hills sites; Mike Shchepanek (The Canadian Museum of Nature) for locating H.J. Scoggan's original data file record of M.E. Moodie's 1914 collection from the Rosedale location, and to Dr. Marcia Waterway (McGill University), Dr. Paul M. Catling (Agriculture and Agri-food Canada) and Christine Niezgoda (Vascular Plant Herbarium, Field Museum, Chicago, IL) for their searches for the actual Rosedale specimen; Bonnie Heidel (Wyoming Natural Diversity Data Center) for sharing her information on the species' habitats and distribution in Wyoming and Montana, and for providing the invaluable correspondence with Walter Fertig (Grand Staircase-Escalante National Monument) on his knowledge of the locations and habitats for the species in Wyoming and Montana; Dr. C.C. Chinnappa (University of Calgary) for allowing access to the herbarium collections; Bob Hale (Duchess Community Pasture Association) and Fred Wittig (Landowner, Burstall, SK) for providing grazing management information on the locations under their management in Alberta; Jane Lancaster (Kestrel Consulting) for sharing her information on the species in Alberta; Garry C. Trottier (CWS) for updated information on the species' location in Canadian Forces Base Suffield National Wildlife Area; Dr. Geoffrey L. Holroyd (CWS) for information on remaining native prairie in western Canada; and Hugh D.J. McLean (Agriculture and Agri-Food Canada) for information on prairie climate and drought conditions.

Preparation of this report was funded by the Alberta Conservation Association and the Fish and Wildlife Division of Alberta Sustainable Resource Development.

For the 2009 update prepared by Cheryl Bradley:
The assistance and contributions of several people in the preparation of this report is gratefully acknowledged. Lorne Fitch assisted with field work in 2008. Todd Kemper (Alberta Natural Heritage Information Centre) provided data on occurrences of slender mouse-ear-cress in Alberta and worked to jointly resolve issues about the definition of subpopulations. Gavin Berg (Alberta Sustainable Resource Development, ASRD) assisted in acquiring background information. Ian Macdonald (botanical consultant) provided background information on the 2005 status report that he wrote and reviewed collections of slender mouse-ear-cress in the University of Calgary herbarium. Bonnie Smith (botanical consultant) provided information on previous field work and collections. Ihsan Al-Shehbaz (Missouri Botanical Garden) provided label information for an

historical collection near Rosedale and insights into revisions to the taxonomy of slender mouse-ear-cress. Darcy Henderson and Candace Neufeld (Canadian Wildlife Service, CWS) shared information on occurrences of slender mouse-ear-cress in Saskatchewan, key field identification characters and appropriate survey techniques. Bonnie Heidel (Wyoming Natural Diversity Database), Peter Lesica (University of Montana) and Scott Mincemoyer (Montana Natural Heritage Program) helped with obtaining information on occurrences in Montana. Information on recent rare plant search effort in potential habitat for slender mouse-ear-cress was shared by fellow botanists Dana Bush (Bush Ecology), Jane Lancaster (Kestrel Research), Clare and Kathy Tannas (Rangeland Consultants), and Cliff Wallis (Cottonwood Consultants), as well as by Albert Lees (Jacques Whitford Axys Ltd.). Velma Hudson (Alberta Conservation Association, ACA) helped with production of maps. This report benefited from reviews by Bonnie Smith, Dana Bush, Sue Peters (ACA), Gavin Berg and Robin Gutsell (ASRD).

Preparation of this report was funded by the Alberta Conservation Association and the Fish and Wildlife Division of Alberta Sustainable Resource Development.

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INTRODUCTION

Slender mouse-ear-cress (*Halimolobos virgata* [Nutt.] O.E. Schulz; recently changed to *Transberingia bursifolia* subsp. *virgata*) is an annual, biennial or short-lived perennial herbaceous plant found in mixedgrass prairie on the plains of southwest Saskatchewan and southeast Alberta, and in the Sweetgrass Hills of northern Montana. It is also distributed across the semi-arid mountain ranges and intervening basins and plateaux of seven western states, from eastern California and central Colorado north to southwest Montana and northwest Wyoming. The other subspecies of *Transberingia bursifolia* in Canada occurs north of the Arctic Circle. Despite extensive survey effort in Alberta, the known population of slender mouse-ear-cress is estimated to be in the order of several thousand (3000–7000) reproducing individuals in years when conditions are favourable. Loss of native grasslands within the range of slender mouse-ear-cress is reducing habitat quality and availability.

Slender mouse-ear-cress is considered *May Be At Risk** according to the 2005 general status review (Alberta Sustainable Resource Development [ASRD] 2007). Evaluation of the 2005 slender mouse-ear-cress status report (ASRD 2005) resulted in a recommendation of *Data Deficient* in 2005 (Alberta Endangered Species Conservation Committee Scientific Subcommittee 2005). In Saskatchewan, slender mouse-ear-cress is listed as *Threatened* under that province's *Wildlife Act* (Government of Saskatchewan 2008). Based on an assessment by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2000, slender mouse-ear-cress is listed as *Threatened* in Canada, and is on Schedule 1 of the federal *Species at Risk Act* (COSEWIC 2000, Government of Canada 2008).

* See Appendix 1 for definitions of selected status designations.

The purpose of this report is to summarize current and historical data on slender mouse-ear-cress in Alberta, in order to re-assess the status of this species and develop conservation strategies.

SPECIES TAXONOMY

Slender mouse-ear-cress from the western United States and Canada was originally named *Sisymbrium virgatum* Nutt ex Torrey & A. Gray in 1838. In 1924, it was re-named *Halimolobos virgata* (Nutt.) O.E. Schulz. Recently, the taxon has been included in a new genus *Transberingia*, based on analysis of DNA sequences in related taxa (Price et al. 2001, Al-Shehbaz and O'Kane 2003). Slender mouse-ear-cress is classified by some taxonomists as a species *Transberingia virgata* (Nutt.) N.H. Holmgren (Holmgren et al. 2005) and by others as a subspecies *Transberingia bursifolia* subsp. *virgata* (Nutt.) R.A. Price, Al-Shehbaz & O'Kane (Price et al. 2001).

The new genus *Transberingia* includes two other taxa: *Halimolobos mollis* (Hooker) Rollins from Alaska, Yukon, Nunavut, Northwest Territories, and Greenland; and *Arabidopsis bursifolia* (de Candolle) Botschantsev from the Russian Far East. These two taxa are now classified as one species *Transberingia bursifolia* (de Candolle) Al-Shehbaz & O'Kane and also as one subspecies *Transberingia bursifolia* subsp. *bursifolia* (Al-Shehbaz and O'Kane 2003, Price et al. 2001).

The key distinguishing feature that separates slender mouse-ear-cress from closely related taxa is the presence of multi-branched subappressed hairs (trichomes) sometimes mixed with simple hairs on the upper parts of the stem and central axis of the inflorescence (rachis), instead of only sparse simple hairs or none at all.

The genus *Halimolobos* has been redefined based on DNA sequencing to include eight

species in the southwestern United States and northern and central Mexico, all characterized by having fruits with large hairs mixed with smaller ones (Bailey et al. 2007). Slender mouse-ear-cress and other species in the genus *Transberingia* are described as having no hairs on the fruits, although some recent collections of slender mouse-ear-cress from Saskatchewan are reported to have fruits with hairs (C. Neufeld pers. comm.). More taxonomic investigation of the prairie population of slender mouse-ear-cress is suggested to ascertain the degree to which the population presents distinctive features when compared to populations of the same or closely related taxa several hundreds of kilometres to the southwest and to the north.

Halimolobos virgata continues to be a widely accepted scientific name by North American agencies, other organizations and taxonomic specialists at the time of writing this report (Integrated Taxonomic Information System 2009). Authors of a key for the Mustard family (Brassicaceae) being drafted for *The Flora of North America* consider the taxon as *Transberingia bursifolia* ssp. *virgata* (Al-Shehbaz in prep.).

HABITAT

1. Habitat Attributes - In Alberta, slender mouse-ear-cress is found in the Dry Mixedgrass Natural Subregion of the Grassland Natural Region (Alberta Natural Heritage Information Centre [ANHIC] 2005), in the lower South Saskatchewan River and Red Deer River basins. The climate is continental, characterized by extremes in temperatures with warm summers and cold winters. In the Dry Mixedgrass Natural Subregion the mean annual temperature is 4.2°C, the mean July temperature is 18.5°C, and the mean January temperature is -12.1°C (Natural Regions Committee 2006). There is an average of 113 frost-free days per year, and the average number of growing degree days during the growing season, April through August, is 1318, the highest of any natural region in Alberta. Growing degree days is a cumulative measure of the temperature above 5°C that indicates energy available for plant growth. Average annual precipitation is 333 mm; of that, 241 mm falls during the growing season. The summer moisture index (degree days divided by mean precipitation) averages 7.0, the highest (and hence, driest) of any natural subregion in Alberta. A summer moisture index higher than 4.0 indicates that significant moisture deficits are likely for extended periods during the growing season (Natural Regions Committee 2006). High summer temperatures, low summer precipitation, drying winds, and intense sunshine contribute to the high moisture deficits in midsummer. Low winter snowfalls contribute little to soil moisture reserves.

In Alberta, slender mouse-ear-cress grows on silty to sandy parent material of glaciofluvial (deposited by glacial meltwater), fluvial (deposited by rivers/streams) or eolian (deposited by wind) origin on undulating to rolling sandy plain and river valley slopes and terraces (Bradley 2008). It may occur on sandy fluvial veneer over moderately calcareous till. It is reported near, but not in, choppy sand hills or dunes. Elevation varies from 600 m to 750 m. Habitat is generally described as dry to mesic.

Slender mouse-ear-cress grows mainly on soils that are classified as orthic brown chernozems and are of coarse texture (sandy loams or sands) in sandy ecological/range sites (Adams et al. 2005). Soil map units in which slender mouse-ear-cress has been reported include Bingville-Cavendish (BVCV), Cavendish (CVD), Vendisant-Cavendish (VSCV), Foremost-Purple Springs (FMPL) and Pemukan (PUN), all characterized as coarse-textured fluvial or fluvial veneer over till (Kjearsgaard and Pettapiece 1986). One location is in an area of intersection of a sandy Cavendish-Purple Springs (CVPL) map unit with a Foremost (FMT) map unit characterized as medium-textured, moderately calcareous till. One

location is in a Rough Broken (RB1) map unit that is undifferentiated parent material of river valleys.

It is suggested that slender mouse-ear-cress may be associated with ephemerally wet depressions and drainages that experience a slight alkalization of soils (Environment Canada 2009, Smith 1992, C. Bradley pers. obs.). It is also suggested that at some sites slender mouse-ear-cress preferentially occurs in the shelter of shrubs and cacti, perhaps relying on extra spring moisture from trapped snow (D. Bush pers. comm.). Small-scale habitat associations for slender mouse-ear-cress are not well documented and require further investigation.

Slender mouse-ear-cress usually occurs in native mixed grassland dominated by needle-and-thread grass (*Stipa comata*). Bare soil without vegetation is seldom more than 10 percent of the area of the ecological community. Co-dominant grasses may include blue grama grass (*Bouteloua gracilis*), Sandberg's bluegrass (*Poa sandbergii*), June grass (*Koeleria macrantha*), northern wheatgrass (*Elymus lanceolatus*) or western wheatgrass (*Pascopyrum smithii*). Low sedge (*Carex stenophylla*) may also have more than 10 percent cover. Habitat may include scattered clumps of sagebrush (*Artemesia cana*) and prickly pear cactus (*Opuntia polycantha*).

In southwestern Saskatchewan, slender mouse-ear-cress is found in mixed grassland habitats similar to those in Alberta (Environment Canada 2009). In addition to occurring on chernozemic soils of sandy to loamy texture on fluvial or eolian deposits, it is reported to inhabit sites with regosolic soils and lacustrine deposits. It is most commonly found in native grassland communities dominated by June grass, needle-and-thread grass and wheat grasses, often with some sagebrush or prickly pear cactus. Slender mouse-ear-cress is reported to be occasionally associated with wild rose (*Rosa woodsii*), snowberry (*Symphoricarpos occidentalis)* and silverberry (*Eleagnus commutata*). The non-native invasives, Kentucky bluegrass (*Poa pratensis*) and crested wheatgrass (*Agropyron cristatum*), have been reported at a few sites where slender mouse-ear-cress is found (Environment Canada 2009). Historically, slender mouse-ear-cress was reported from "meadows" in the Cypress Hills in Saskatchewan and Wood Mountain; however, these occurrences have not been relocated (ASRD 2005, Environment Canada 2009).

In the United States, sites where slender mouse-ear-cress has been reported range from valley bottoms to ridge tops, from 1000 m to 3600 m in elevation (Al-Shehbaz in prep.). In the Sweetgrass Hills of north-central Montana, slender mouse-ear cress was found at 1402 m in grassland dominated by needle-and-thread grass, western wheatgrass and Idaho fescue (*Festuca idahoensis*) on thin soils over glacial gravels (collection of June 13, 1989 by E.C. Darfler, Gray Herbarium #246362) (B. Heidel pers. comm., S. Mincemoyer pers. comm., Gray Herbarium 2009). In the Tendoy Mountains of southwest Montana, slender mouse-ear-cress occurs in open shrublands dominated by big sagebrush and mountain mahogany on valley terraces at 1700 m to 2300 m (Montana Field Guide 2008, University of Montana Herbarium 2008, P. Lesica pers. comm.). In Wyoming, it is reported mostly in montane habitats, especially sagebrush communities in the vicinity of calcareous rock outcrops (ASRD 2005). In northeast Utah, slender mouse-ear-cress is associated with moist loamy to gravelly substrates at 2100 m to 2700 m. At the southwest limit of its range in east-central California, slender mouse-ear-cress occurs in "meadows" and seeps in pinyon-juniper woodland at 2000 m to 3000 m (Calflora 2008, California Native Plant Society 2008).

2. Habitat Trends - Grasslands are one of North America's most threatened ecosystems (Gauthier et al. 2003). Mixedgrass and shortgrass prairie have been reduced to

20%–30% of their former extent, the decline caused primarily by agriculture expansion, urban development, oil and gas development and the construction of transportation and utility corridors. In Alberta, native prairie is estimated to have declined by 60%–70% since colonization in the late 1890s (Alberta Environmental Protection 1997, Alberta Prairie Conservation Forum 2000). The Dry Mixedgrass Natural Subregion has a higher proportion of intact grasslands remaining (about 55%) than other subregions of the Grassland Natural Region; however, the extent to which these are in native condition is not well documented.

Native prairie continues to decline because of human activities and the spread of invasive non-native species in fragmented landscapes. The energy sector footprint has been increasing at a rate of about 9000 hectares per year across the Grassland Natural Region (Prairie Conservation Forum 2008). A cumulative effects assessment of a regional study area extending from Medicine Hat to the Red Deer River and from the west boundary of the Canadian Forces Base (CFB) Suffield to Highway 41 estimates bare ground resulting from agriculture (cultivation) and industrial development has increased from 10.2 ha/km^2 in 1970 to 14.3 ha/km^2 in 2005, an increase of 40% (Environment Canada 2008a). Linear disturbance has increased from 2.7 km/km^2 to 5.2 km/km^2, an increase of 93%, over the same thirty-five year period. This trend is expected to continue.

Several major pipelines and gas fields have been developed over the last decade in native grasslands within the known provincial range of slender mouse-ear-cress and more development is proposed. Gas field development with densities up to 16 wells per section (6 wells per km^2) has resulted in total disturbed area of up to 12% and linear disturbance footprint of up to 12 km/km^2 (Smith and Tulis 2007). The Great Sand Hills Advisory Committee (2007) considers anthropogenic disturbance footprint of more than 1.9 km/km^2 to be "highly developed."

A modified plant community is associated with anthropogenic disturbances in mixedgrass prairie, not only in areas where vegetation and soil have been directly impacted by the land use but also indirectly through invasion of non-native species into adjacent areas of native vegetation (AXYS 2005, Bradley 2003, Great Sand Hills Advisory Committee 2007, Henderson 2007, Rowland 2008, Smith 2007, Smith and Taylor 2007, Smith and Tulis 2007). Invasive, non-native species commonly found in grasslands in southern Alberta include crested wheatgrass (*Agropyron cristatum*), Kentucky bluegrass (*Poa pratensis*), smooth brome (*Bromus inermis*), downy brome (*Bromus tectorum*) and leafy spurge (*Euphorbia esula*). Once established, these invasive species persist.

Crested wheatgrass establishes in habitats suitable to slender mouse-ear-cress (Bradley 2008). It is reported to spread by seed into native grasslands at rates up to 0.8 m/year (Henderson 2007, Henderson and Naeth 2005). Crested wheatgrass is associated with decreased plant community diversity, decreased soil organic matter and reduced carbon sequestration (Christian and Wilson 1999, Heidinga and Wilson 2002, Henderson and Naeth 2005, Jordan et al. 2008).

Leafy spurge also establishes in habitats suitable to slender mouse-ear-cress (Bradley 2008). It is reported to spread by seed and roots into native grasslands at rates of up to one metre per year (National Park Service 2003). Leafy spurge outcompetes native species by shading, usurping available water and nutrients, and through plant toxins that prevent the growth of other plants underneath it (National Park Service 2003).

One location where slender mouse-ear-cress was reported in 1884 (Medicine Hat [EO

008]) is no longer suitable habitat as a result of anthropogenic disturbance for municipal development and establishment of crested wheat grass. At a location where slender-mouse-ear-cress was reported in 1978 (Sandy Point, north of McNeill [subEO 002]), surveyors undertaking subsequent searches noted a modified plant community dominated by crested wheatgrass (ASRD 2004, Macdonald 2002). Two other locations where slender mouse-ear-cress has not been found during surveys within the last 10 years (west of McNeill [EO 005]; north of Duchess [EO 009]) have experienced establishment of modified plant communities as a result of development of a pipeline corridor, gas wells and access roads (Bradley 2008). Leafy spurge invasion has been noted at one location of slender mouse-ear-cress (south of Empress [EO 017]). Long-term impact of invasive, non-native species on slender mouse-ear-cress presence is not known (Environment Canada 2009).

A conclusion from the information provided in this section is that a large portion of potential native upland and river valley habitat for slender mouse-ear-cress has been lost owing to human activity over the last century. Substantial further loss is predicted if current trends in land use and non-native plant species invasion continue without measures being taken to identify and protect sites where slender mouse-ear-cress occurs.

CONSERVATION BIOLOGY

Slender mouse-ear-cress is a biennial or sometimes short-lived perennial or annual herb in the mustard family (Brassicaceae) (Kershaw et al. 2001, Moss 1983). The plant is tap-rooted and rosette-forming with one to several erect, simple or branched stems 10 cm–40 cm tall. Plants vary greatly in stature, from tall, branched and robust to short, single-stemmed and thin. A feature that distinguishes slender mouse-ear-cress from mustards of similar appearance, including *Arabis hirsuta* and *Erysimum inconspicuum*, is that the upper stem generally has longer straight, simple or forked hairs (trichomes) mixed with shorter, freely branching hairs. Leaves of the basal rosette are up to 6 cm long and 15 mm wide, tapered to the stalk and wavy-toothed. Stem leaves are smaller, the upper leaves stalkless and clasping with small basal lobes (auricles). Numerous small flowers, about 4 mm–8 mm across, occur on stalks clustered at the tip of the stem. Each flower has four white petals and four hairy sepals. The flowering stem (a raceme) elongates in fruit such that the linear pods (siliques) are erect and borne on stalks 7 mm–11 mm long that usually extend at a 45 degree angle from the stem. Pods are 2 cm–4 cm long and 1 mm wide, generally hairless and cylindrical. Seeds are crowded in two irregular rows in each of two locules.

Other mustards of similar appearance occurring in habitat similar to slender mouse-ear-cress can be distinguished in fruit by having flattened pods (*Arabis holboellii* var. *retrofracta, Arabis divaricarpa, Arabis hirsuta*) or four-angled pods with a beak and seeds in one row in each locule (*Erysimum spp.*). Stems of *Erysimum* spp. have only simple or forked (malpighian) hairs, often dense, and lack the scattered, shorter freely-branching hairs characteristic of slender mouse-ear-cress.

In Alberta, slender mouse-ear cress has been reported bearing flowers and immature fruit during mid-May to late June and bearing mature fruit and dispersing seed during late June to mid-July (ASRD 2005, ANHIC 2008, B. Smith pers. comm.). Each stem bears up to two dozen flowers and each linear pod contains a few dozen seeds; therefore, individual plants on average likely produce between 100 and 400 seeds (ASRD 2005). Further study would be required to determine whether pollination in slender mouse-ear-cress is wind- or insect-mediated, and whether self-fertilization occurs. Seeds are small (<1 mm) and wingless, with a seed coat that is minutely reticulate. The pods

split open at maturity while still attached to the plant, readily dispersing the seeds, most of which likely fall near the parent plant, although some may be carried farther by wind, water or animals. Leaves rapidly dry up, stems turn brittle and do not appear to persist long after seed dispersal (C. Bradley pers. obs., C. Neufeld pers. comm.).

There is no information on seed longevity, the rates of seed germination, or survival rates of seedlings for slender mouse-ear-cress. The first year following seed germination, a tap root and rosette of leaves may grow. A flowering stem is generally produced in one or more subsequent years. Little information is available on how long individual plants live. For many years slender mouse-ear-cress was described as biennial, occasionally annual (Moss 1983); however, more recent taxonomic treatments consider it a perennial, perhaps short-lived (Price et al. 2001).

There is evidence that the number of plants at one location may fluctuate substantially from year to year, suggesting that local weather conditions influence seed production, seed germination and plant growth. Slender mouse-ear-cress may be associated with habitats that are wet in the spring (Environment Canada 2009). Lower than average precipitation in a given year may suppress germination and growth, resulting in underestimation of size and extent of a population. Therefore, surveys are best planned for years when there is above average precipitation during April, May and June.

Slender mouse-ear-cress appears to be tolerant of light to moderate livestock grazing pressure. It does not appear to be preferentially selected by grazers and may be avoided. It is classified as tolerant of heavy grazing pressure in range surveys in Wyoming (ASRD 2005). In locations with heavy livestock use, slender mouse-ear-cress is generally found close to shrubs and cacti, suggesting these plants shelter it from grazing and trampling (D. Bush pers. comm.). Slender mouse-ear-cress is not obviously a disturbance-dependent species, although small disturbances, such as the action of hoofs exposing bare soil or creating moist depressions may provide suitable microhabitats for its establishment. Periodic fire may also benefit slender mouse-ear-cress by releasing nutrients and removing competition of grasses and shrubs.

DISTRIBUTION

1. Alberta – All reports of slender mouse-ear-cress in Alberta are within the Dry Mixedgrass Natural Subregion of the Grassland Natural Region, and more specifically, in the watersheds of the Red Deer River below Drumheller and the South Saskatchewan River below Medicine Hat (Figure 1). Occurrences are concentrated in the Bindloss Plain Ecodistrict (Adams et al. 2005). This Ecodistrict is characterized as having surficial materials predominantly of glaciofluvial and eolian origin and the highest annual moisture index (ratio of total annual degree days to total annual precipitation) in the Dry Mixedgrass Natural Subregion.

Fourteen occurrences or subpopulations make up the known population of slender mouse-ear-cress in Alberta, as of January 2009. These element occurrences are listed in Table 1 and mapped in Figure 1. Where information on genetics and propagule dispersal is lacking, element occurrences are defined as separate populations no less than 1 km apart if intervening habitat conditions are unsuitable, and no more than 3 km apart if intervening habitat conditions are suitable for the species (NatureServe 2004). Of the fourteen slender mouse-ear-cress occurrences in Alberta, one is considered extirpated, one is considered historical, three are considered failed-to-find and nine are considered extant (ANHIC 2008, Hammerson et al. 2008).

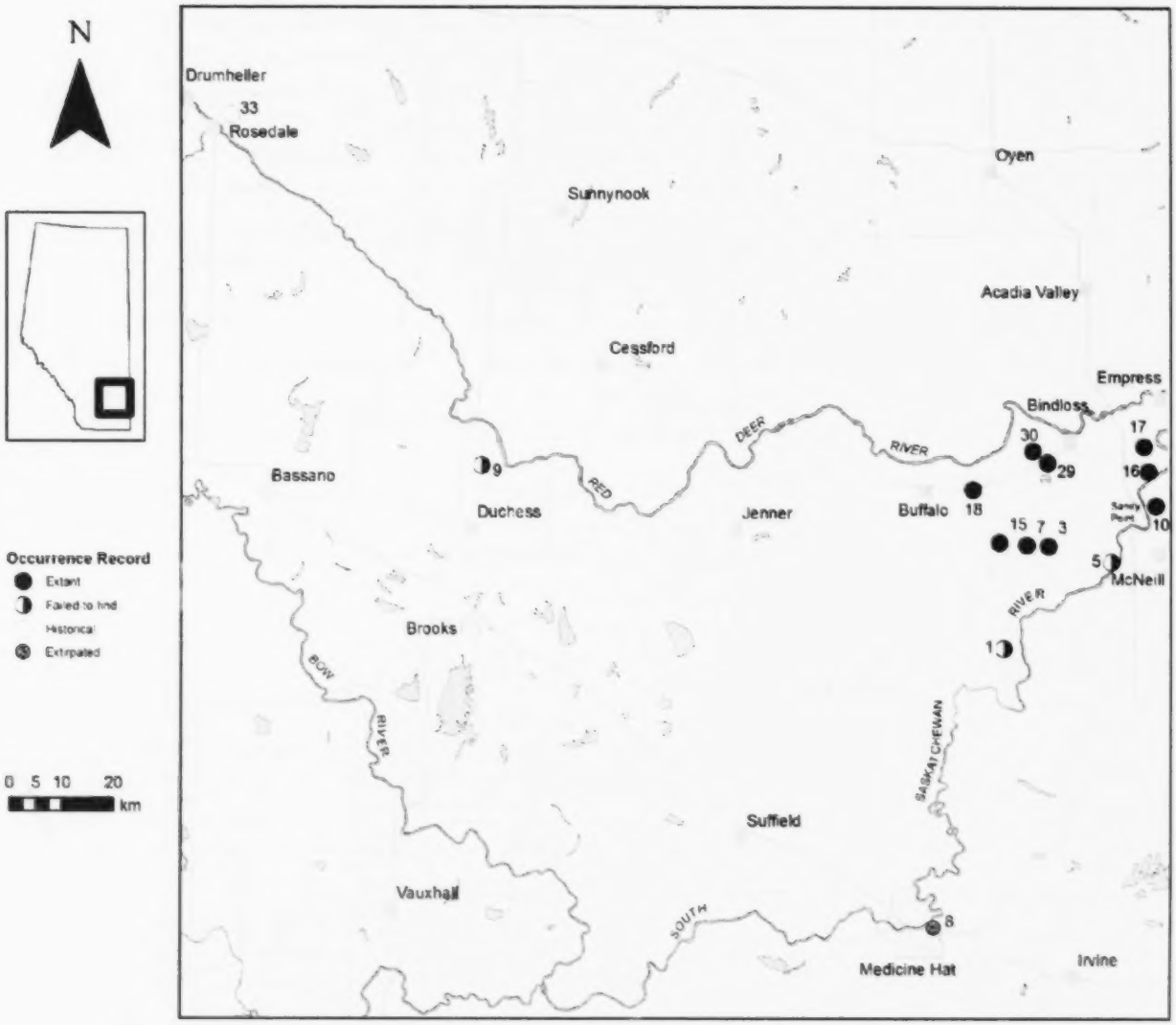

Figure 1: Occurrence record locations for slender mouse-ear-cress in Alberta. See Table 1 for information on each record. Occurrence numbers are assigned by the Alberta Natural Heritage Information Centre.

The first collection of slender mouse-ear-cress in Alberta was made in 1894 by John Macoun near the police barracks at Medicine Hat, known as Police Point (EO 008 in Table 1). The collection is filed with the Canadian Museum of Nature National Herbarium. This occurrence is considered extirpated because substantial habitat alteration has occurred as a result of municipal development, and slender mouse-ear-cress has not been found during subsequent rare plant surveys in and near Medicine Hat. A second collection by John Macoun, generally described as from the Cypress Hills, has been determined to be likely from Saskatchewan and not Alberta (ASRD 2005).

The second collection of slender mouse-ear-cress was made in 1914 by M.E. Moodie in "the vicinity of Rosedale in prairies north of the Red Deer Valley at 2200-2500 ft on damp soil near sloughs" (EO 033 in Table 1) (Al-Shehbaz pers. comm.). The collection, only recently

Table 1: Summary of data on number of plants for occurrences/subpopulations of slender mouse-ear-cress in Alberta. Data are from the Alberta Natural Heritage Information Centre (ANHIC) database of rare plant occurrences; element occurrence (EO) numbers and ranks are assigned by ANHIC. See Figure 1 for occurrence locations. EO Rank: H = historical; F = failed-to-find; E = extant; X = extirpated. N/a indicates that data are not available.

Site Name	EO# (sub)	EO Rank	Max. Recorded Pop. (Year)	Survey Date(s)	Population Estimate[1]	Area (m^2)
Rosedale	033	H	>1 (1915)	1915-06-05	>1	n/a
Duchess Pasture; Matzhiwin Creek	009	F	49 (1997)	1997-06-02	54	25
				2002-xx-xx	0	0
				2005-05-20	0	0
				2008-06-16	0	0
W of Remount Pasture; N Boundary CFB Suffield	015	E	47 (2008)	2008-07-02	47	300
Cavendish; Remount Pasture NW	018	E	87 (2008)	2008-07-05	87	600
Remount Pasture S; N Boundary CFB Suffield	007	E	398 (2004)	1997-05-31	0	0
				2002-xx-xx	0	0
				2004-06-07	398	1200
				2008-07-02	25	400
Remount Pasture SE;	003	E	919 (2004)	1997-05-30	15	900
				1997-05-30	1	<1
				1997-05-30	200	1500
				2002-xx-xx	0	0
				2004-06-26	919	1000
Bindloss SW; Remount Pasture NE	029	E	96 (2007)	2007-05-29	96	n/a
				2008-06-06	15	160
Bindloss W; Minor Ranch	030	E	130 (2007)	2007-05-27	130	n/a
				2008-06-13	1	<1
Empress S; Big Loop S. Sk. R.	016	E	7 (2008)	2008-07-03	7	10
Empress; Big Loop S. Sk. R.	017	E	15 (2008)	2008-07-03	15	10
Linstead Flats; CFB Suffield National Wildlife Area	001	F	20 (1995)	1995-06-23	20	375
				2004-xx-xx	0	0
				2005-06-26	0	0
S Sk. R. pipeline crossing; W of McNeill	005	F	>100 (1997)	1997-05-29	>100	200
				2002-xx-xx	0	0
				2004-xx-xx	0	0

Table 1 continued.

Site Name	EO# (sub)	EO Rank	Max. Recorded Pop. (Year)	Survey Date(s)	Population Estimate[1]	Area (m^2)
McNeill N	010[2]	E	251(2007)	1997-05-24	56	200
				1997-05-24	16	20
				1997-05-24	33	30
				1999-07-12	12	200
				2002-xx-xx	0	0
				2004-06-06	145	100
				2004-06-24	39	10
				2004-09-14	14	n/a
				2007-07-01	8	n/a
				2007-07-02	21	n/a
				2007-07-02	2	n/a
				2007-07-02	150	250
				2007-07-02	21	n/a
				2007-07-27	36	1114
				2007-07-27	2	n/a
				2007-07-27	2	10
				2007-07-27	7	3
				2007-07-27	1	<1
				2007-07-27	1	<1
				2008-06-15	17	400
				2008-06-15	13	n/a
				2008-07-01	13	n/a
				2008-07-02	29	16
(McNeill N, Sandy Point; Hwy 41 at S. Sk. R.)	(002)[2]	(F)	>1(1978)	1978-05-16	>1	n/a
				1991-06-07	0	0
				1997-05-24	0	0
				2002-xx-xx	0	0
				2003-xx-xx	0	0
Police Point; Medicine Hat	008	X	>1 (1884)	1884-05-31	>1	n/a
				1991-06-07	0	0
				2002-xx-xx	0	0

[1] Population estimate is the number of individuals counted in a cluster or several clusters, as reported to ANHIC. Multiple (sub)population estimates on the same date apply to different plant clusters within the same subpopulation.

[2] Sub EO 002 has recently been included in EO 010 and is not shown on the map in Figure 1. For three decades it was considered a separate EO, and is the only known site within the subpopulation located west of the river.

relocated, is filed with the Missouri Botanical Garden (Moodie #949). This occurrence is considered historical, since slender mouse-ear-cress has not been reported from the vicinity in several decades (ANHIC 2008); however, targeted search in the vicinity has yet to be conducted.

Six decades elapsed before slender mouse-ear-cress was collected again, in 1978 by John Hudson at Sandy Point north and east of the Highway 41 Bridge in the South Saskatchewan River valley (EO 010, subEO 002; Table 1). A collection (#335977) is filed at the Agriculture Canada Herbarium in Ottawa. In four separate searches since 1991, surveyors have failed to

find slender mouse-ear-cress on the terraces where the collection was made, noting considerable invasion by crested wheatgrass (ASRD 2004, Macdonald 2002, Smith 1992 and 2000). This location is now considered part of a larger element occurrence extending to the east and south (EO 010).

In 1995, slender mouse-ear-cress was collected in upland sand plain habitat during an inventory of vascular plants in the Canadian Forces Base Suffield National Wildlife Area (EO 001; Table 1) (Macdonald 1997). Collections are filed with the University of Calgary herbarium and the Provincial Museum in Edmonton (B95.9.6). Surveyors failed to find plants during searches at this location, near Linstead Flats, in 2004 and 2005 (Elchuk 2005); hence, this occurrence is considered failed-to-find.

In 1997, seven new upland occurrences of slender mouse-ear-cress (EO 003, EO 005, EO 006, EO 007, EO 009, EO 010 and EO 032; see Table 1) were reported during a rare plant survey along a proposed pipeline route between the Alberta/Saskatchewan border near McNeill and westward to beyond Matzhiwin Creek near Duchess (Smith 2000). Locations were identified as distances along the pipeline and legal land descriptions (section/township/range), and not by more precise GPS coordinates (B. Smith pers. comm.). Population size included counts of plants of the current year and also counts of plants identified as "old stems" from the previous year. Three Alberta collections of *Halimolobos virgata* and one Saskatchewan collection filed at the University of Calgary herbarium included dried-up stems and remnants of pods from the previous year that have been re-identified as *Erysimum* spp. (C. Bradley pers. obs., I. Macdonald pers. comm., B. Smith pers. comm). All element occurrences documented by B. Smith included plants of the current year except the two element occurrences in the Buffalo Atlee Pasture that were recorded solely on the basis of "old stems" (EO 006 and EO 032). These two element occurrences were recorded as "invalid identification" in 2009 (T. Kemper pers. comm.), and are therefore not included in Table 1 or Figure 1. Four Alberta collections of slender mouse-ear-cress from locations identified in the 1997 survey are filed at the University of Calgary herbarium: Duchess Pasture EO 009 (UAC 56451) Remount Pasture 003 EO (UAC 56455) and near McNeill EO 010 (UAC 56454 , UAC 56457).

Several subsequent intense and targeted searches between 1997 and 2008 resulted in confirmation of the presence of slender mouse-ear-cress at three locations, two in the Remount Pasture and one near McNeill (EO 003, EO 007 and EO 010) and failure to find it at four locations (EO 005, EO 009, EO 006 and EO 032; the latter two were subsequently found to be invalid, as described above). Additional surveys are needed to determine with confidence if slender mouse-ear-cress is extirpated at the two occurrences where surveyors have failed to find previously reported populations in over a decade—the Duchess Pasture near Matzhiwin Creek (EO 009) and the pipeline corridor crossing of the South Saskatchewan River (EO 005). Alteration of native plant communities because of major pipeline corridor construction and gas field development may be contributing to the plant's absence.

In 2007, during rare plant survey along a proposed pipeline route from Hardisty south through McNeill and eastward, slender mouse-ear-cress was found at two new locations south of the Red Deer River near Bindloss (EO 029 and EO 030; Table 1). The extent of the subpopulation near McNeill (EO 010) was extended northward to the proposed pipeline crossing of the South Saskatchewan River about 7 km downstream of Sandy Point, based on several new reports during the 2007 and 2008 surveys (D. Bush pers. comm., C. Tannas pers. comm., A. Lees pers. comm.).

In 2008, four new occurrences of slender mouse-ear-cress were reported during a targeted

survey in apparently suitable habitat (Bradley 2008). One of these new occurrences is along the northern boundary of CFB Suffield, a few kilometres west of the Remount Pasture (EO 018; Table 1). Another occurrence is a few kilometres south of the Red Deer River between Cavendish and Buffalo (EO 015; Table 1), and two others are about 5 km apart south of Empress and west of the South Saskatchewan River where it loops into Saskatchewan (EO 016 and EO 017; Table 1).

Over the last few decades, several rare plant surveys have not reported any occurrences of slender mouse-ear-cress in apparently suitable sand plain and river valley habitat in Alberta. Slender mouse-ear-cress was not found in extensive survey of sand hill and sand plain habitats of southern Alberta in 1987 (Wallis and Wershler 1988). Neither was it found during more recent rare plant surveys within the CFB Suffield National Wildlife Area (Elchuk 2005), the Onefour Research Station (Bradley et al. 2006), the Many Island Lake area (C. Wallis pers. comm.) and public lands leased to the Drowning Ford Grazing Association and Hargraves Ranch (J. Lancaster pers. comm.). During the last 10 years, rare plant surveys in other sand plain habitats of southeast Alberta conducted as part of environmental assessments for proposed pipeline routes or gas field developments have resulted in few, if any, reports of slender mouse-ear-cress, even though the considerable search effort was targeted towards slender mouse-ear-cress and other priority species at risk (ASRD 2004 and 2008, J. Lancaster pers. comm., D. Bush pers. comm.). In addition, systematic and intensive search effort in 2008 specifically of habitat considered to have high potential for slender mouse-ear-cress, resulted in no occurrences in 14 of 18 quarter sections searched using parallel, randomly spaced transects (Bradley 2008).

The extent of occurrence of slender mouse-ear-cress is the area within a polygon made by drawing straight lines between the most northerly, westerly, southerly and easterly occurrences. A polygon that encompasses only occurrences ranked as extant, including mostly sand plain and choppy sand hills, is about 530 km^2 in area (G. Berg pers. comm.). This area increases to 2930 km^2 when all occurrences considered extant or failed-to-find are included, and 9998 km^2 when all reported occurrences in Alberta (even those ranked as extirpated or historical) are included (G. Berg pers. comm.). At least half of the habitat within the extant range (530 km^2) of slender mouse-ear-cress in Alberta has been converted to non-native vegetation and a considerable portion of the native habitat is unsuitable including shrublands, wetlands and alkaline flats, till ridges, rolling sand dunes, eroding slopes and rivers or streams. A similar proportion of the range that includes all reported occurrences (9998 km^2) is unsuitable for slender mouse-ear-cress.

The known area of occupancy, defined as the area within the extent of occurrence occupied by slender mouse-ear-cress excluding unsuitable or unoccupied habitat (IUCN 2001), is estimated to be less than 0.05 km^2 using data from Alberta Natural Heritage Information Centre (ANHIC) occurrence records. There are 33 unique locations of slender mouse-ear-cress in ANHIC reports (based on UTM coordinates) and the maximum population extent for any one location is 1500 m^2 (Table 1), implying that area of occupancy for all known locations is unlikely to exceed 0.05 km^2 (33 x 1500 m^2). Slender mouse-ear-cress plants are found in small discrete patches and seeds appear to fall close to the parent plants; hence area between patches is considered to be unoccupied.

Potential area of occupancy may also be estimated to be less than 0.05 km^2 if one applies the percentage area of suitable habitat occupied by slender mouse-ear-cress, derived from results of the systematic 2008 survey, over the total extent of extant occurrences (530 km^2).

Eighteen quarter sections with apparently suitable habitat were surveyed along up to ten randomly-spaced, parallel transects in each quarter section (Bradley 2008). The sampling approach gives an 80% to 90% probability of detection, assuming an area of occupancy of 0.1% of the study area (D. Henderson pers. comm.). The total area occupied by the four populations found in 2008 was 920 m^2 out of a total search area of approximately 11.5 km^2; hence, only about 0.01% of apparently suitable habitat searched was found to be occupied by slender mouse-ear-cress.

The area of occupancy calculated by summing occupied 1-km x 1-km squares (excluding failed-to-find, extirpated and historical occurrences) results in an area of 18 km^2 (or 52 km^2 using 2-km x 2-km squares, the International Union for Conservation of Nature standard [IUCN 2001] but less biologically relevant for this species).

2. Other Areas – In Saskatchewan, slender mouse-ear-cress is known from 13 locations, plus three additional historical locations that have not been relocated (C. Neufeld pers. comm.) (Figure 2). Historical locations include one in Wood Mountain and two in the Cypress Hills. Extant populations occur north and west of the South Saskatchewan River between Riverhurst and Outlook (Riverhurst, Birsay, Macrorie, Coteau, Lucky Lake), northeast of Kindersley (Stranraer), near Estuary on the South Saskatchewan River (Estuary, Alkali Creek) and in the Great Sand Hills (Golden Prairie, East Fox, Liebenthal). The closest known location to Alberta is within the Prairie National Wildlife Area Unit 20, approximately 45 km directly east of Alberta's McNeill location. Native prairie on sand plain contiguous with known habitat for slender mouse-ear-cress near McNeill appears to extend 10-15 km into Saskatchewan; however, survey for slender mouse-ear-cress has not yet been conducted in this area (C. Neufeld pers. comm.).

In Montana, slender mouse-ear-cress was found in 1989 in the East Butte uplift of the Sweetgrass Hills (SE6-36-5 E 5M), approximately 3 km north/northeast of the summit of Mount Brown and about 10 km south of the border with Alberta (Gray Herbarium 2009, Westech 1989). This is within Liberty County about 200 km south of McNeill. Collections from Sheridan and Phillips counties in northeastern Montana originally identified as *Halimolobos virgata* have been re-identified as *Arabis hirsuta* (University of Montana Herbarium 2008). All other known Montana locations of slender mouse-ear-cress are a further 450 km south in the Tendoy Mountains of Beaverhead County in the southwest part of the state (P. Lesica pers. comm.). The nearest population in Wyoming is also 450 km south of the Sweetgrass Hills in the Absaroka Range of the northwest part of the state (University of Wyoming 1998).

Elsewhere in the United States, slender mouse-ear-cress is known from northeastern Idaho (Butte county), central and western Wyoming (several counties), central Colorado (Gunnison and Park counties), northeastern Utah (Dagget and Wasatch counties), southwest Nevada (Esmeralda and Nye counties) and east central California (Inyo and Mono counties) (NatureServe 2009, Al-Shehbaz in prep.) (Figure 2).

POPULATION SIZE AND TRENDS

1. Alberta – There are insufficient data to confidently estimate the size of the provincial population of slender mouse-ear-cress, in terms of number of individuals. Survey methods used in acquiring existing data are generally not well defined and likely vary greatly, thereby confounding meaningful comparisons among locations and years. With these provisos, a population size of 3000–7000 individuals is estimated based on the data currently available.

Figure 2: Distribution of slender mouse-ear-cress in North America (based on information available from NatureServe 2009).

For slender mouse-ear-cress, an individual is defined by a basal leaf rosette. Reproductive plants will have a flowering shoot or stem associated with a basal rosette, whereas non-reproductive plants will not. In addition, viable seeds in the soil are part of the non-reproductive population but are not readily counted. The most practical and efficient unit for monitoring population size of slender mouse-ear-cress is the flowering shoot (Henderson 2008).

The number of reproductive individuals within a subpopulation, as variously defined in reports filed with ANHIC, ranges from 1 to 919 (Table 1, ANHIC 2008). The distribution of plants within known subpopulations (separated by no more than 3 km) varies from one small cluster of one or a few individuals to several scattered clusters of several to many individuals. The three largest known subpopulations, in terms of extent and size, are one north of McNeill and east of the South Saskatchewan River (EO 010) and two along the northeast boundary of CFB Suffield in the Remount Pasture (EO 003 and EO 007).

There are more data for the McNeill subpopulation than any other subpopulation (EO 010, Table 1). Data consist of reports of slender mouse-ear cress at approximately 20 unique sites (based on GPS coordinates provided by surveyors) over 11 years (1997–2008) (Table 1), in an area approximately 10 km by 3 km (30 km^2) east of the South Saskatchewan River to the Alberta-Saskatchewan border. Most of the survey effort has been focused along two proposed pipeline rights-of-way and has not included a systematic approach to estimating total population size. Reported plant clusters range in size from 1 individual to 150 individuals and in density from 36 individuals in 1114 m^2 (0.03 plants/m^2) to 39 individuals in 10 m^2 (3.9 plants/m^2). The population size also varies over time. During a spring survey in 1997, 104 individuals were reported in three clusters; in 1999, only 12 individuals were reported at the same sites; in 2002, no individuals were found; and, in 2004, 184 individuals were reported in two clusters. In 2007, 251 individuals were reported in 11 clusters throughout a larger area compared to previous surveys. From these data one can estimate there are several hundred (300–700) reproducing individuals in the McNeill subpopulation in a year with suitable conditions for germination and growth, and there are large fluctuations in the number of reproducing individuals from year to year.

Data on the two southern Remount Pasture subpopulations (EO 003 and EO 007), along the boundary with CFB Suffield, consist of three to four records at each location (Table 1). Reports of size for the most easterly subpopulation (EO 003) are, in 1997, 216 individuals in three clusters; in 2002, no individuals; and, in 2004, 919 individuals in 1000 m^2. Reported clusters are scattered over a 3-km distance, east to west. Reports of size for the second subpopulation (EO 007) are, in 1997 and 2002, no individuals; in 2007, 398 individuals in 1200 m^2; and, in 2008, 25 individuals in 400 m^2. From these data we can conclude that there are several hundred (300–700) individuals in each of the two Remount Pasture subpopulations, and perhaps a few thousand (1000–3000) individuals in a year with suitable conditions for germination and growth. As well, there is evidence for large fluctuations in the number of reproducing individuals from year to year. These two subpopulations are separated by approximately 3 km; however, the intervening habitat is native grassland on sandy parent material and additional survey may determine that the two subpopulations are one. Suitable habitat for slender mouse-ear-cress also occurs a few hundred metres south of these subpopulations within CFB Suffield; however, a major pipeline corridor, vehicle trail, fenceline and road bisect what once was contiguous habitat.

Another subpopulation (EO 015) of slender mouse-ear-cress along the north boundary of CFB Suffield and west of the Remount Pasture is separated from the nearest subpopulation

(EO 007) by five kilometres and a till ridge. In 2008, the only year of record, the subpopulation was reported to have 47 individuals in 300 m^2.

Two subpopulations (EO 029 and EO 030) about 15 km north of CFB Suffield's northern boundary near Bindloss have reported maximums of 130 and 96 individuals, respectively, in 2007, and much reduced numbers in 2008. These two subpopulations are separated by 3 km, including a broad corridor of disturbance resulting from railway line and highway construction; hence there is unlikely to be sufficient genetic exchange between these two subpopulations to consider them one. In 2008, about 15 km to the west along Highway 555 near Cavendish, another subpopulation (EO 018) was reported to have 87 individuals in a 600 m^2 area.

A subpopulation (EO 005) of about 100 individuals scattered in small clusters of 3–7 stems over an area of about 200 m^2 was reported in 1997. This subpopulation occurs on upland grassland west of the South Saskatchewan River near where a pipeline corridor crosses the river about 12 km upstream of the Highway 41 bridge (Smith 2000, Smith pers. comm.). It is about 8 km west of McNeill and about 8 km east of the CFB Suffield's eastern boundary. Two subsequent searches in the area failed to find slender mouse-ear-cress.

Three subpopulations are reported to have fewer than 20 individuals. A subpopulation (EO 001) in CFB Suffield about 20 km south of the northern boundary was reported, in 1995, to have 20 individuals in 375 m^2. No individuals have been found there in two subsequent surveys. Two subpopulations (EO 016 and EO 017) south of Empress are reported, in 2008, to have only 7 and 15 reproducing individuals, respectively, and are separated by 5 km. The intervening habitat is native grassland on sandy substrate; hence, additional search effort may find these two subpopulations to be one.

The disjunct subpopulation (EO 009) near Matzhiwin Creek north of Duchess was characterized as having 54 individuals in "several small patches over 2 km" when first found in 1997 (Smith 2000). No slender mouse-ear-cress has since been found during several searches at this location. This subpopulation is separated by over 160 km from the nearest subpopulations in the Remount Pasture. Much of the intervening area is considered unsuitable habitat for slender mouse-ear-cress, given that surficial deposits are not fluvial-eolian sands but rather till, lacustrine silts and clays and eroded bedrock of the Dinosaur badlands (Kjearsgaard and Pettapiece 1986).

Based on the data available, the provincial population of slender mouse-ear-cress is estimated to be in the order of several thousands (3000–7000) of reproducing individuals in years when conditions are suitable for germination and growth. To accurately define population size and trends, known locations would need to be surveyed over a period of several years using a well-defined monitoring protocol designed to meet a specified degree of statistical confidence with respect to population size and extent (Elzinga et al. 1998, Henderson 2008). As well, a systematic approach to searching for additional subpopulations would be required. Environmental stochasticity and observation error pose challenges, as does the invisibility of the seed bank (Brigham and Thomson 2003, Elderd et al. 2003, Alexander et al. 2009).

2. Other Areas – In Saskatchewan, the maximum population of slender mouse-ear-cress recorded at one of the 13 extant locations is 3678 individuals; four subpopulations are reported to have 100–150 individuals; three have 20–40 individuals; three have fewer than five individuals; and, two lack count data with no plants found in recent survey (C. Neufeld pers. comm., Environment Canada 2009). More systematic surveys for slender mouse-ear-cress in the Great Sand Hills in 2006, 2007 and 2008 are providing baseline data for more

confidently estimating population size and monitoring long-term trends.

No information is available on population size of slender mouse-ear-cress in the United States.

LIMITING FACTORS

Limiting factors are major factors that affect habitat quality and availability, reproductive output, or survival of individuals. The focus is on factors that have an anthropogenic origin. The effects of limiting factors may be cumulative.

1. Loss and Degradation of Habitat – Loss of native grasslands within the range of slender mouse-ear-cress continues to affect habitat quality and availability. Native prairie decline is caused primarily by agriculture expansion, urban development, oil and gas development and the construction of transportation and utility corridors, as well as the spread of invasive non-native species in fragmented landscapes. Information on loss of native grasslands within slender mouse-ear-cress range is provided in the Habitat section of this report. Key points are summarized as follows:

- Over the last century, approximately 50% of the Dry Mixedgrass Natural Subregion in southeast Alberta has been converted from native vegetation to a completely altered state by human land uses (Alberta Environmental Protection 1997).
- Since 1970, in a study area that encompasses all of the provincial range of extant slender mouse-ear-cress subpopulations, bare ground resulting from agriculture (cultivation) and industrial development has increased 40% (from 10.2 ha/km^2 to 14.3 ha/km^2) (Environment Canada 2008a). In the same period linear disturbance has increased 93% (from 2.7 km/km^2 to 5.2 km/km^2).
- A subpopulation (EO 008) of slender mouse-ear-cress has been extirpated as a result of municipal development.
- Habitat for eight subpopulations of slender mouse-ear-cress has been altered within the last few decades by gas field and major pipeline corridor development (EO 009, EO 015, EO 007, EO 003, EO 029, EO 030, EO 005, EO 010).
- As the amount of anthropogenic edge in native prairie increases, the potential for invasion of non-native species increases. Invasion of non-native species, especially crested wheat grass, from human disturbances is adversely affecting the quality of slender mouse-ear-cress habitat.

Further loss or alteration of habitat for slender mouse-ear-cress is predicted if current trends in land use continue.

Recently, the Joint Review Panel of the Canadian Environmental Assessment Agency and the Energy Resources Conservation Board recommended developing a management strategy for non-native invasive plant species to protect native prairie integrity in the Suffield National Wildlife Area (Joint Review Panel 2009). The National Wildlife Area includes known habitat for slender mouse-ear-cress. The Joint Review Panel also recommended excluding industrial disturbance in critical habitat for slender mouse-ear-cress unless otherwise specifically permitted.

2. Anthropogenic Climate Change - Population data suggest that annual weather influences germination and growth of slender mouse-ear-cress. For example, the absence of slender mouse-ear-cress rosettes and stems in 2002 at locations where previously there had been many individuals may be explained by lower than average precipitation in May 2002; less than 10 mm measured at Empress and Bindloss compared to an average of 40 mm (Environment Canada 2008b). Relatively high numbers of individuals found in 2007 may be explained by higher than average precipitation in May 2007; 57 mm measured at Bindloss (Empress data not available). It can be assumed that predicted

change in climate because of human activities will affect slender mouse-ear-cress reproduction and survival, as well as its habitat.

Slender mouse-ear-cress occurs in that part of Alberta with the highest potential for significant moisture deficits during the growing season, that is the Bindloss Plain Ecodistrict of the Dry Mixedgrass Natural Subregion. Predictions are that this area will experience up to a 4°C increase in mean annual temperature by the 2020s, mostly occurring in winter and spring, and up to a 20% increase in mean annual precipitation mostly occurring in winter and spring (Sauchyn and Kulshreshtha 2007); however, summers will be especially dry. A trend of increased aridity will most likely be realized through a greater frequency of dry years. Also predicted are increased climate variability and more frequent extreme events, including a greater frequency of flooding and severe drought.

Higher precipitation in spring may increase germination and growth of slender mouse-ear-cress, especially if the species is associated with vernal pools, although this has not yet been confirmed. Increased summer drought may negatively affect seed viability and survival of plants that only appear as rosettes in a given year. The prairie population of slender mouse-ear-cress in Alberta and Saskatchewan has survived drought in the past, including that of the 1930s. However, occurrences in the United States (where most of the species' range is) are at considerably higher elevations, 1000 m–3600 m, compared to elevations of 600 m–750 m in Canada, suggesting an affinity to cooler and moister growing season conditions than are predicted for the mixedgrass prairie region with climate change.

Movement of slender mouse-ear-cress northward as vegetation shifts in response to climate change may be restricted by lack of contiguous corridors and blocks of native mixedgrass prairie on sandy substrates.

3. Altered Fire Regime – Absence of fire may be affecting the slender mouse-ear-cress population in Alberta. For millennia, fire started by lightning or humans was a constant presence in mixedgrass prairie, fluctuating with regional climate change, vegetation change, and cultural change. Fires ranged in size from less than a hectare to several thousand hectares and had return intervals from 0–35 years with mean intervals of 4–10 years (Henderson 2006). Fire helped to maintain a shifting mosaic of large ungulate grazing pressure on the landscape and played a role in soil organic matter formation.

Such a pervasive disturbance in the ecosystem likely influenced the evolution and distribution of slender mouse-ear-cress. Fire may affect these and other herbaceous plants by reducing competition from perennial grasses and shrubs for space and resources, stimulating or suppressing seed germination and sprouting of dormant roots, enhancing growth by increasing organic matter in the soil, or directly killing rosettes and reproductive shoots.

Today, fire suppression is practiced throughout the range of slender mouse-ear-cress. Alteration of the fire regime, beyond the range of natural variation in fire as an ecosystem process, is likely resulting in more vegetation and litter cover and less bare soil in the mixedgrass prairie habitats of slender mouse-ear-cress. The implications for this species are unknown.

Recently the Joint Review Panel of the Canadian Environmental Assessment Agency and the Energy Resources Conservation Board recommended take measures "that are necessary and safe" to restore the natural fire regime to the Suffield National Wildlife Area, which includes known habitat for slender mouse-ear-cress (Joint Review Panel 2009).

4. Altered Grazing Regime – For millennia, grazing by herbivores such as bison, pronghorn, elk, deer, small mammals and insects was a constant presence in the prairie habitats of

slender mouse-ear-cress. Size, shape, spatial distribution and the succession in grazed patches varied across the landscape over time, depending on when, how long, how often and how intensively the mix of native herbivores grazed. Environmental modifications brought about by grazing animals contribute to variety in habitats and biodiversity in the landscape (Romo 2007).

Such a pervasive disturbance in the ecosystem likely influenced the evolution and distribution of slender mouse-ear-cress. Grazing may affect herbaceous plants such as slender mouse-ear-cress by reducing competition from perennial grasses and shrubs for space and resources, creating openings that stimulate or suppress seed germination and sprouting of dormant roots, enhancing growth by increasing nutrients in the soil, suppressing growth through soil compaction, dispersing seed, or directly killing rosettes and reproductive shoots through browsing and trampling. Today, slender mouse-ear-cress is found in areas that receive light to moderate livestock grazing pressure.

In the 1800s, introduction of cattle meant going from an open system, where grazing patterns were climatically defined, to a closed system where management dictates pattern, timing and intensity of grazing. The implications for slender mouse-ear-cress of this altered grazing regime, beyond the range of natural variation in grazing as an ecosystem process, are unknown.

STATUS DESIGNATIONS*

1. Alberta – The evaluation of a detailed status report for slender mouse-ear-cress (ASRD 2005) under the provincial Species At Risk Program resulted in an assessment of *Data Deficient* in 2005 (Alberta Endangered Species Conservation Committee Scientific Sub-committee 2005). Slender mouse-ear-cress is considered *May Be At Risk* according to the general status review (ASRD 2007). It is also currently ranked as S1S2 in Alberta (Gould 2006).

2. Other areas - Based on an assessment by COSEWIC, slender mouse-ear-cress was designated *Endangered* in Canada in April 1992. Its status was re-evaluated and designated *Threatened* in Canada in May 2000 (Environment Canada 2009). It is listed on Schedule 1 of the federal *Species at Risk Act* (Government of Canada 2008). In Saskatchewan, slender mouse-ear-cress is ranked as S1 and is listed as *Threatened* under the province's *Wildlife Act* (Government of Saskatchewan 2008). Nationally, in Canada slender mouse-ear-cress has a rank of N2 (NatureServe 2009). A draft recovery strategy for slender mouse-ear-cress in Canada has recently been developed (Environment Canada 2009).

In the United States, known locations of slender mouse-ear-cress are limited to one or a few counties within each of the states in which it occurs (except for Wyoming). Slender mouse-ear-cress is ranked as S1 in Utah, California and Colorado, S3 in Montana and Wyoming, and SNR in Idaho and Nevada (NatureServe 2009, Al-Shehbaz in prep., B. Heidel pers. comm.). Detailed status evaluations of slender mouse-ear-cress within these jurisdictions are lacking. Nationally, in the United States it is ranked as N3 and globally as G4 (NatureServe 2009).

RECENT MANAGEMENT IN ALBERTA

No specific management activities for the protection of slender mouse-ear-cress have been undertaken in Alberta. Because slender mouse-ear-cress is listed as *Threatened* in Schedule 1 of the federal *Species at Risk Act*, provincial managers require that development proposals involving potential habitat on provincial land include rare plant surveys. If slender mouse-

* See Appendix 1 for definitions of selected status designations.

ear-cress is found, steps must be taken to avoid adverse affects on the local subpopulation.

Provincial representatives have cooperated with representatives of Environment Canada, Agriculture and Agri-Food Canada and the Government of Saskatchewan in preparing a national recovery strategy for slender-mouse-ear-cress through the National Recovery Team for Plants at Risk in the Prairie Provinces (Environment Canada 2009). Consultation is occurring with Department of National Defence, industry stakeholders, First Nations, and environmental non-government organizations. The strategy has yet to be officially approved and implemented.

Slender mouse-ear-cress occurs along the proposed route of the TransCanada Keystone Pipeline project. The National Energy Board (NEB) approved the project in September 2007. An environmental screening report completed by the NEB requires specific mitigation be developed, in consultation with Alberta Sustainable Resource Development and Environment Canada, to minimize effects on rare plants, and that mitigation be incorporated into the Environmental Protection Plan and the Operations Vegetation Management Plan for the project (National Energy Board 2007).

There is one occurrence of slender mouse-ear-cress recorded in the CFB Suffield National Wildlife Area, an area managed by the Department of National Defence with advice from the Canadian Wildlife Service of Environment Canada. A proposed shallow gas infill development project in the National Wildlife Area was recently the subject of a panel review of the Canadian Environmental Assessment Agency and the Energy Resources Conservation Board. The report of the Joint Review Panel (2009) includes recommendations for finalizing critical habitat of slender mouse-ear-cress, using mapped critical habitat as exclusion areas if the project proceeds (unless otherwise permitted under the *Species at Risk Act*), and ensuring a monitoring program is implemented to evaluate the effects of the project.

SYNTHESIS

Slender mouse-ear-cress (*Halimolobos virgata* (Nutt.) O.E. Schulz) is an annual, biennial or short-lived perennial herbaceous plant that recently has undergone taxonomic revision to *Transberingia bursifolia* subsp. *virgata*. In Alberta, slender mouse-ear-cress is found within the lower South Saskatchewan River and Red Deer River basins in the Dry Mixedgrass Natural Subregion. Its habitat is native grassland on silty to sandy parent material of glaciofluvial, fluvial or eolian origin on undulating to rolling sandy plain and river valley slopes and terraces. Slender mouse-ear-cress appears to be associated with ephemerally wet depressions and drainages.

Fourteen subpopulations are recognized: one is ranked as extirpated, one as historical, three as failed-to-find, and nine as extant. Extant occurrences are concentrated in the Bindloss Plain Ecodistrict. The historical extent of occurrence of all subpopulations is about 9998 km^2; that of only extant ones is about 530 km^2. Area of occupancy estimated from element occurrence data is less than 0.05 km^2; calculated by summing occupied 1-km x 1-km squares results in an area of occupancy of 18 km^2. Substantial rare plant search effort over the last few decades, and particularly within the last few years, has resulted in reports of only a few localized subpopulations of slender mouse-ear-cress within apparently suitable habitat.

Estimates of reproducing individuals of slender mouse-ear cress at the 14 known occurrences range from 1 to 919 plants, and data over multiple years at some sites suggest large fluctuations, depending on environmental conditions such as timing and amount of rainfall in spring. The provincial population of slender mouse-ear-cress is estimated to be in the order

of several thousand (3000–7000) reproductive individuals in years when conditions are suitable for germination and growth.

Loss of native grasslands within the range of slender mouse-ear-cress continues to affect habitat quality and availability. Native prairie decline is caused primarily by agriculture expansion, urban development, oil and gas development and the construction of transportation and utility corridors, as well as the spread of invasive non-native species in fragmented landscapes. Since 1970, bare ground resulting from agriculture (cultivation) and industrial development has increased 40% and linear disturbance has increased 93% in a study area that encompasses all of the range of extant slender mouse-ear-cress subpopulations. Other potential limiting factors are climate change and altered fire and grazing regimes beyond the range of natural variation.

To accurately define population size, extent and trends, known locations will need to be surveyed over a period of several years using a well-defined monitoring protocol designed to meet a specified degree of statistical confidence with respect to population size and extent. As well, a systematic approach to searching for additional subpopulations will be required similar to that used by Bradley (2008).

Alberta's extant population of slender mouse-ear-cress is approximately 45 km from the closest known subpopulation in Saskatchewan and 200 km from the nearest population in Montana. No genetic exchange is expected. Future survey is needed to determine if there is a subpopulation in Saskatchewan contiguous with the McNeill subpopulation in Alberta. In addition, more taxonomic investigation of the prairie population of slender mouse-ear-cress is suggested to ascertain the degree to which there are features distinct from populations of slender mouse-ear-cress several hundreds of kilometres to the north and to the southwest (Environment Canada 2009).

Slender mouse-ear-cress was designated as *Endangered* by COSEWIC in 1992 and re-assessed as *Threatened* in 2000. It is listed on Schedule 1 of the federal *Species at Risk Act*. In Saskatchewan, slender mouse-ear-cress is listed as *Threatened* under the province's *Wildlife Act*. A draft recovery strategy for slender mouse-ear-cress in Canada has recently been developed.

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Appendix 1: Definitions of status ranks and legal designations.

A. The General Status of Alberta Wild Species 2005 (after Alberta Sustainable Resource Development 2007)

2005 Rank	1996 Rank	Definitions
At Risk	Red	Any species known to be *At Risk* after formal detailed status assessment and designation as *Endangered* or *Threatened* in Alberta.
May Be At Risk	Blue	Any species that may be at risk of extinction or extirpation, and is therefore a candidate for detailed risk assessment.
Sensitive	Yellow	Any species that is not at risk of extinction or extirpation but may require special attention or protection to prevent it from becoming at risk.
Secure	Green	Any species that is not *At Risk, May Be At Risk* or *Sensitive*.
Undetermined	Status Undetermined	Any species for which insufficient information, knowledge or data is available to reliably evaluate its general status.
Not Assessed	n/a	Any species that has not been examined during this exercise.
Exotic/Alien	n/a	Any species that has been introduced as a result of human activities.
Extirpated/Extinct	n/a	Any species no longer thought to be present in Alberta (Extirpated) or no longer believed to be present anywhere in the world (Extinct).
Accidental/Vagrant	n/a	Any species occurring infrequently and unpredictably in Alberta, i.e., outside its usual range.

B. Alberta Species at Risk Formal Status Designations
Species designated as *Endangered* under Alberta's *Wildlife Act* include those listed as *Endangered* or *Threatened* in the Wildlife Regulation (in bold).

Endangered	**A species facing imminent extirpation or extinction.**
Threatened	**A species likely to become endangered if limiting factors are not reversed.**
Species of Special Concern	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Data Deficient	A species for which there is insufficient scientific information to support status designation.

C. Committee on the Status of Endangered Wildlife in Canada (after COSEWIC 2009)

Extinct	A species that no longer exists.
Extirpated	A species that no longer exists in the wild in Canada, but occurs elsewhere.
Endangered	A species facing imminent extirpation or extinction.
Threatened	A species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction.
Special Concern	A species that may become threatened or endangered because of a combination of biological characteristics and identified threats.
Not at Risk	A species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient	A category that applies when the available information is insufficient to (a) resolve a wildlife species' eligibility for assessment, or (b) permit an assessment of the wildlife species' risk of extinction.

D. Heritage Status Ranks: Global (G), National (N), Sub-national (S) (after Alberta Natural Heritage Information Centre 2007, NatureServe 2009)

G1/N1/S1	5 or fewer occurrences or only a few remaining individuals. May be especially vulnerable to extirpation because of some factor of its biology.
G2/N2/S2	6 to 20 or fewer occurrences or with many individuals in fewer locations. May be especially vulnerable to extirpation because of some factor of its biology.
G3/N3/S3	21 to 100 occurrences; may be rare and local throughout its range, or in a restricted range (may be abundant in some locations). May be susceptible to extirpation because of large-scale disturbances.
G4/N4/S4	Typically > 100 occurrences. Apparently secure.
G5/N5/S5	Typically > 100 occurrences. Demonstrably secure.
GX/NX/SX	Believed to be extinct or extirpated; historical records only.
GH/NH/SH	Historically known; may be relocated in the future.
G?/N?/S?	Not yet ranked, or rank tentatively assigned.

E. United States Endangered Species Act (after National Research Council 1995)

Endangered	Any species that is in danger of extinction throughout all or a significant portion of its range.
Threatened	Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

List of Titles in This Series
(as of August 2009)

No. 1 Status of the Piping Plover (*Charadrius melodus*) in Alberta, by David R. C. Prescott. 19 pp. (1997)

No. 2 Status of the Wolverine (*Gulo gulo*) in Alberta, by Stephen Petersen. 17 pp. (1997)

No. 3 Status of the Northern Long-eared Bat (*Myotis septentrionalis*) in Alberta, by M. Carolina Caceres and M. J. Pybus. 19 pp. (1997)

No. 3 Update 2009. Status of the Northern Myotis (*Myotis septentrionalis*) in Alberta. Alberta Sustainable Resource Development and Alberta Conservation Association. 34 pp. (2009)

No. 4 Status of the Ord's Kangaroo Rat (*Dipodomys ordii*) in Alberta, by David L. Gummer. 16 pp. (1997)

No. 5 Status of the Eastern Short-horned Lizard (*Phrynosoma douglassii brevirostre*) in Alberta, by Janice D. James, Anthony P. Russell and G. Lawrence Powell. 20 pp. (1997)

No. 5 Update 2004. Status of the Short-horned Lizard (*Phrynosoma hernandesi*) in Alberta. Alberta Sustainable Resource Development. 27 pp. (2004)

No. 6 Status of the Prairie Rattlesnake (*Crotalus viridis viridis*) in Alberta, by Sheri M. Watson and Anthony P. Russell. 26 pp. (1997)

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